Met Office

Initial assessment of the impact of MetOp-B IASI

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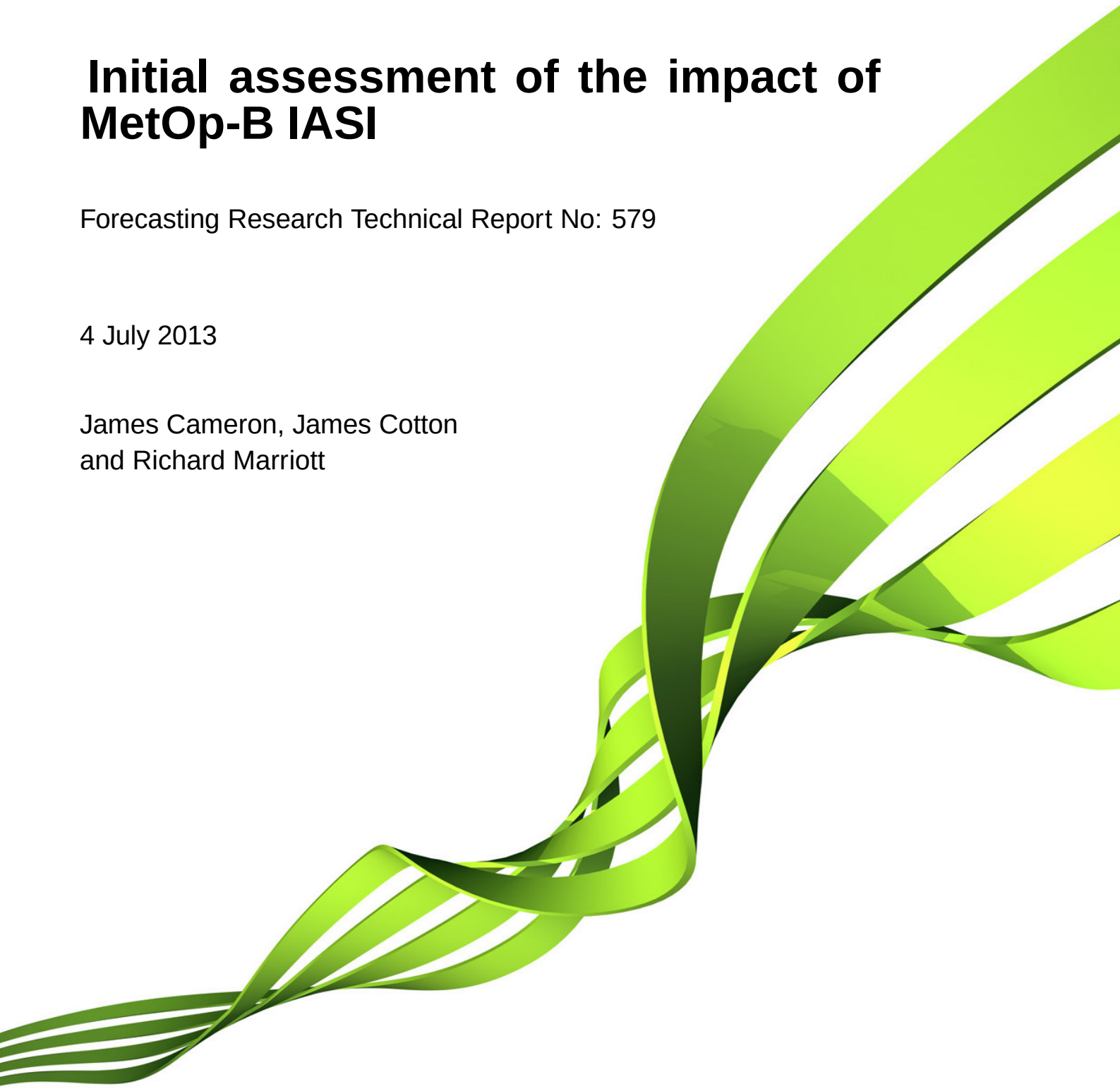

Abstract

MetOp-B IASI data has been assimilated operationally in the Met Office global model since 19 February 2013, resulting in a 20% increase in the number of IASI observations used. The addition of this data not only increases the data coverage, but also increases the robustness of the system to interruptions in the data flow.

Data assimilation experiments have been run for the period 1 February–25 March 2013. The addition of MetOp-B IASI data results in a positive impact of around +0.13 on the NWP index. Thinning the two IASI instruments separately doubles the number of IASI observations used over MetOp-A alone, and gives an additional impact of about +0.06. The fit of forecast fields to observations is generally improved for most forecast fields and at most forecast ranges. The fit of the forecast background to ATOVS, AIRS and MetOp-A IASI observations is also generally improved, although the fit to some of the AMSU-A temperature sounding channels is fractionally degraded.

A forecast sensitivity experiment for the period 23 March–25 April 2013 indicates that the impact per observation for MetOp-B IASI is very similar to that of MetOp-A IASI. This is evidence that MetOp-B IASI is delivering the expected impact.

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1 Introduction

An initial assessment of the impact of MetOp-B IASI observations on forecasts has been carried out. The introduction of MetOp-B IASI data to the operational system is briefly described in section 2, with particular emphasis on the resulting data coverage. The experiments used to assess the impact of MetOp-B IASI are outlined in section 3, and the impacts discussed in section 4. A forecast sensitivity experiment provides evidence that MetOp-B IASI is delivering the expected level of impact per observation, as summarised in section 5. The main conclusions are reiterated in section 6.

2 Operational use of MetOp-B IASI

MetOp-B IASI data has been assimilated operationally in the Met Office global model since 19 February 2013. The decision to begin assimilation of this data was based on a positive assessment of the data quality [1]. The channel selection and instrument errors used for MetOp-A IASI assimilation are the same as those for MetOp-B. The bias correction introduced at this time was based on data from 25 January–12 February 2013.

Figure 1 shows the locations of IASI observations from a typical data assimilation cycle. Most of the observations shown in this plot were received via EUMETCast. However a small number of observations in the vicinity of Europe were received via direct broadcast using a satellite dish based at the Met Office headquarters in Exeter. It was decided to give EUMETCast data priority over locally received data in the stationlist thinning, so not very much local data is used in a typical assimilation cycle. The data is thinned to 154 km in the tropics and 125 km in the extra-tropics. At the time of its introduction, MetOp-B was still in the calibration and validation phase and no forecast impact studies had been carried out. It was accordingly decided to give MetOp-A IASI data priority in the stationlist thinning. The addition of MetOp-B IASI data results in an increase of about 20% in the number of IASI observations assimilated. The MetOp-B data fills the gaps between the MetOp-A swaths, giving more uniform coverage. Since the gaps between the swaths are wider in the tropics, the latitudinal distribution of assimilated observations will not be quite the same for MetOp-B as for MetOp-A.

Assimilating two IASI instruments adds to system robustness because if one instrument drops out briefly then observations from the other instrument will provide continuity. It is possible to thin MetOp-A and MetOp-B IASI data in separate thinning rounds, meaning that similar numbers of MetOp-A and MetOp-B data are assimilated in each cycle, but there is signficant overlap in coverage. Assimilation experiments have been run to assess the additional benefit of thinning separately and they are discussed in the next section.

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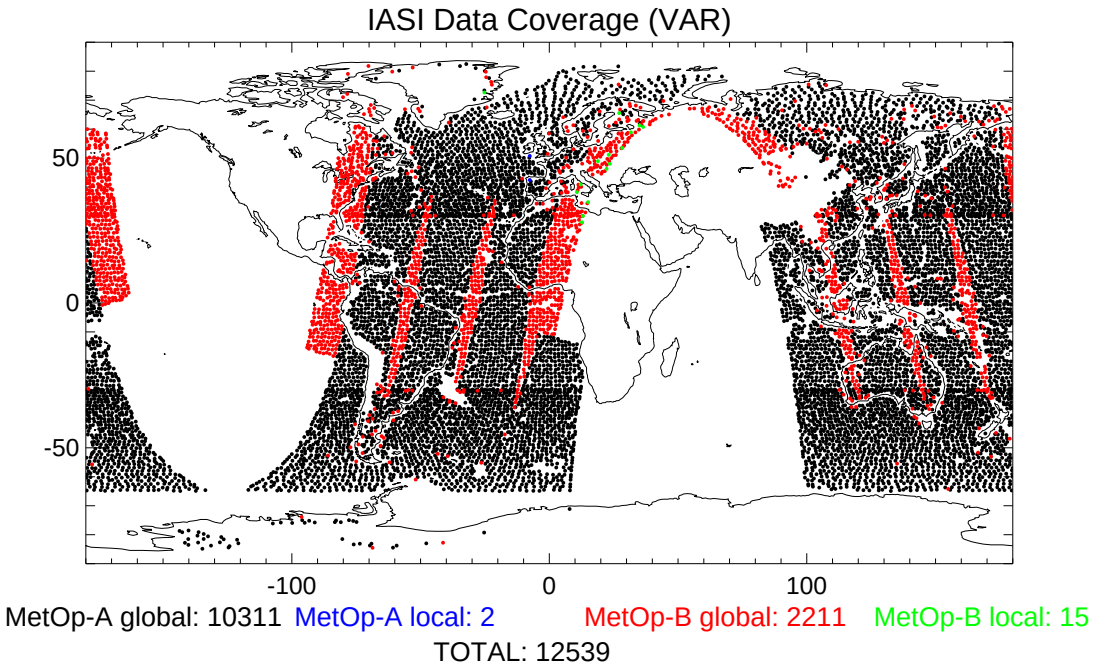

Figure 1: The distribution of IASI observations passed to VAR for a typical data assimilation cycle. MetOp-A observations are shown in black and MetOp-B observations in red. Locally received MetOp-A and MetOp-B IASI data are shown in blue and green respectively, although there are only a few observations of this type.

3 Assimilation experiments

A number of trials were set up based on the operational settings in use after the 19 February 2013 upgrade. Unlike the operational system these trials do not use hybrid error covariances in the data assimilation. The trials span the period 1 February–25 March 2013. The earliest global MetOp-B IASI data stored in the MetDB is for 22 January 2013, so these trials represent the earliest period it is possible to test with MetOp-B IASI. One of the trials includes data from all of MetOp-B IASI, ATOVS, ASCAT and AMVs, whereas in another trial no MetOp-B data was used. A further two trials were run to isolate the impact of MetOp-B IASI. One trial included MetOp-B ATOVS, ASCAT and AMV data, but no MetOp-B IASI. In the other trial both MetOp-A and MetOp-B IASI were used and the data from the two instruments thinned separately. Table 1 gives a summary of these trials:

Trial	Owner	Description
sjcna	J. Cotton	OS31 after 19 February upgrade *minus* all MetOp-B instruments.
sjcnb	J. Cotton	sjcna *plus* MetOp-B IASI, ATOVS, ASCAT and AMVs.
sjfsa	J. Cameron	sjcnb *minus* MetOp-B IASI.
sjfsb	J. Cameron	sjcnb *plus* thinning MetOp-A and MetOp-B IASI separately.

Table 1: A summary of the trials discussed in this report.

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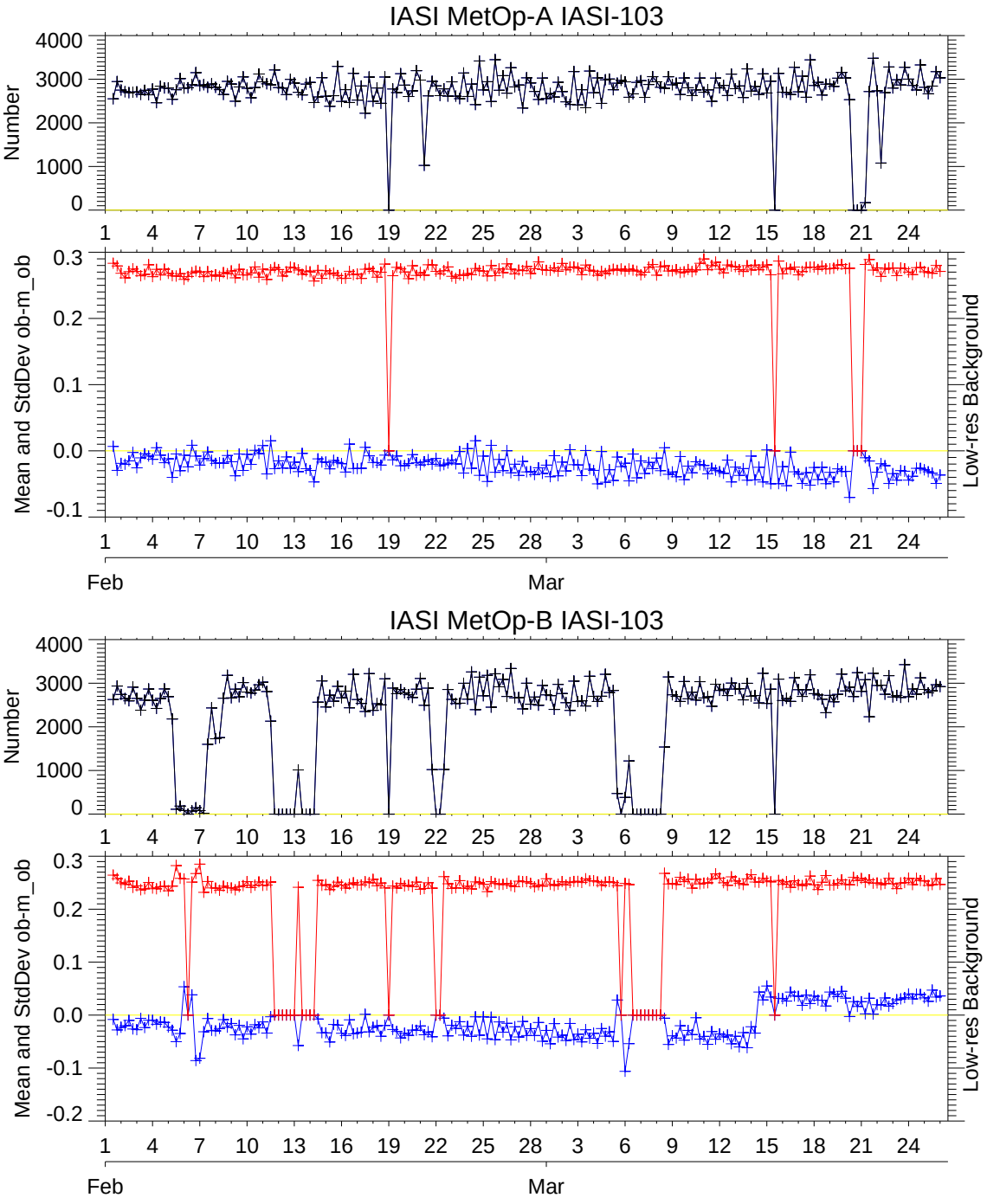

Figure 2: The uppermost graph shows the number of MetOp-A IASI observations where MetDB channel 103 (instrument channel number 371) was assimilated. The next plot shows the mean (blue) and standard deviation (red) of the observed minus forecast background brightness temperatures in VAR. The bottom two plots show the equivalent statistics for MetOp-B.

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Figure 2 shows the number of assimilated MetOp-A and MetOp-B IASI observations that contain MetDB channel 103 (instrument channel number 371) from trial sjfsb. Also shown are the bias and standard deviation of the observations with respect to the forecast background. MetOp-B was still undergoing in-orbit testing during this period of time and as a consequence there are a large number of interruptions to the data flow. The interruptions on 12–14 February, 22 February and 6–8 March were due to the instrument being in external calibration mode. Note that there is a slight shift in bias of channel 103 on 14 March for MetOp-B. This was due to an update to the instrument calibration. Of the assimilated channels, channel 103 was the one for which the bias changed by the greatest amount. There was a further minor change to the MetOp-B calibration on 14 May 2013, and a more significant change to calibration of MetOp-A on 16 May. The operational bias correction was updated on 18 June 2013 to correct for these changes. Note that when MetOp-A and MetOp-B data are both available then very similar numbers of observations are assimilated – which is what we would expect when thinning the data separately.

4 Trial verification

A set of 4 comparisons were made based on the trials listed in table 1. The comparisons and the associated NWP index changes are summarised in table 2 below.

Expt vs Ctrl	Number of days	New NWP Index vs Obs	Ext. Better/ Worse	Old NWP Index vs Obs	Ext. Better/ Worse	Old NWP Index vs Analysis	Ext. Better/ Worse
1. Impact of adding MetOp-B IASI, ATOVS, ASCAT and AMVs.							
sjcnb vs sjcna	52	+0.27	0/0	+0.29	0/0	-0.10	0/0
2. Impact of adding MetOp-B IASI on top of the other MetOp-B instruments.							
sjcnb vs sjfsa	52	+0.13	0/0	+0.23	0/0	0.00	0/0
3. Impact of thinning MetOp-A and MetOp-B IASI separately rather than together.							
sjfsb vs sjcnb	52	+0.06	0/0	+0.12	0/0	-0.17	0/0
4. Impact of thinning MetOp-A and MetOp-B separately versus no MetOp-B IASI.							
sjfsb vs sjfsa	52	+0.18	0/3	+0.35	0/2	-0.17	8/8

Table 2: Table of the trials compared and the resulting NWP index changes. The ‘Ext. Better/Worse’ column indicates the number of entries in the extended verification table where the RMS difference is highlighted as being reduced or increased by more than 2%. There are 567 entries in the extended verification table for the new index and 369 for the old index.

Figure 3 shows the percentage change in the RMS difference between forecast and observations for the fields used in the calculation of the new NWP index. The ‘H’ and the ‘W’ in the forecast field labels stands for height and winds respectively and the number indicates the pressure in hPa. The different forecast ranges are shown in shades of grey.

From table 2, the impact of adding MetOp-B IASI, ATOVS, ASCAT and AMVs, on top of a full system that already includes MetOp-A IASI, is +0.27 on the new NWP index. The first plot in figure 3

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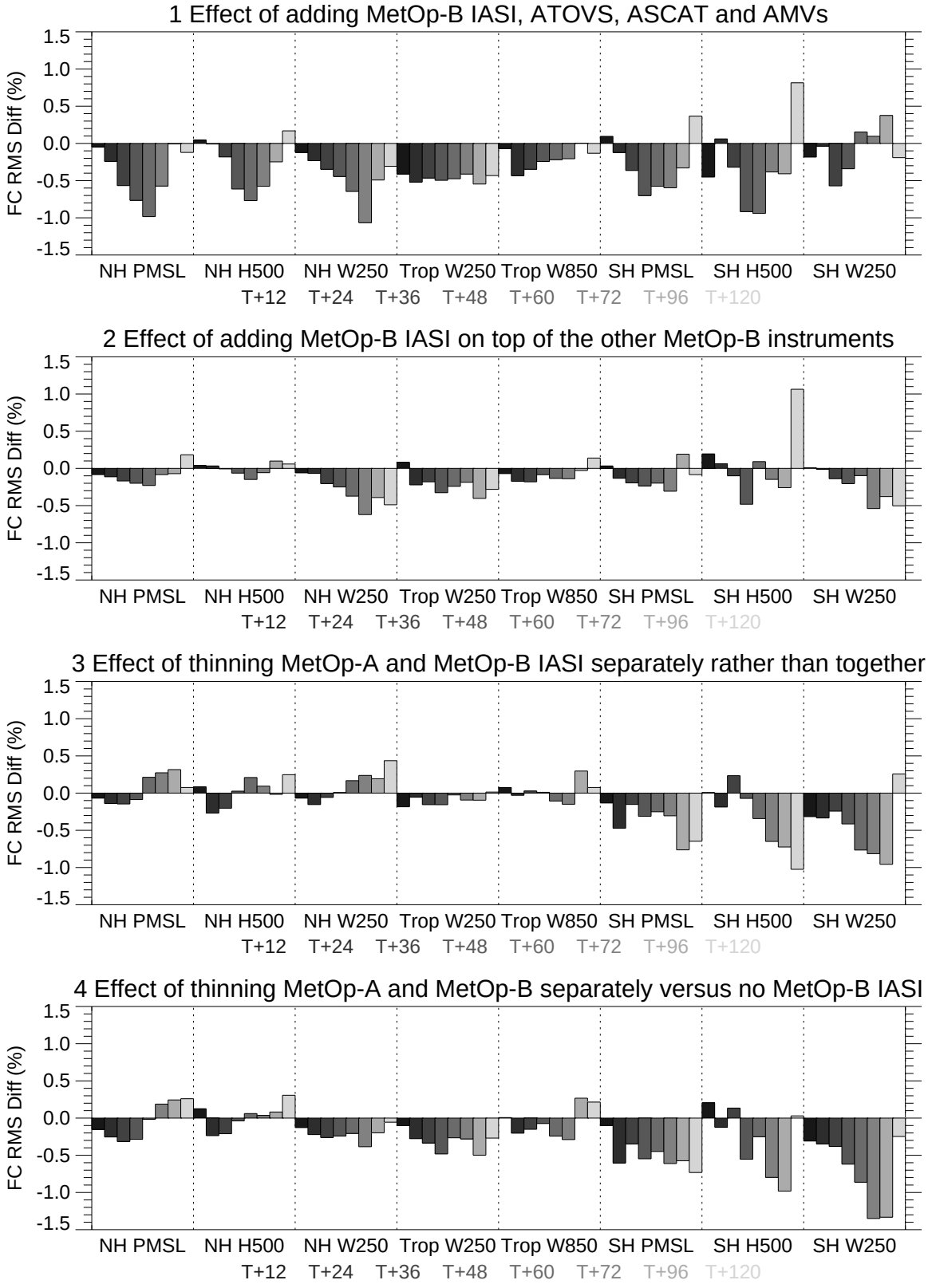

Figure 3: The percentage change of the RMS difference between forecast and observations for the fields used in the calculation of the new NWP index.

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shows consistent improvements for the majority of fields and forecast ranges. Figure 4 shows the percentage reduction in the standard deviation of observed minus forecast background for ATOVS, AIRS and MetOp-A IASI observations. This plot was generated using the VAR statistics from the two trials. The fit to all channels is improved. The little boxes in the ATOVS plot highlight AMSU-A channels 5–9, and MHS channels 3–5. For ATOVS, it can be seen that the water vapour sensitive channels are most improved, specifically HIRS channel 11 and MHS channels 3–5. For AIRS the window channels (approximately MetDB channels 130–180) are significantly improved, as are all the water vapour channels (180 onwards). The window channels have some sensitivity to water vapour which is perhaps the cause of the improvement. The fit to all temperature sounding channels is fractionally improved, although in most cases it is very small. The fit to MetOp-A IASI data is improved in much the same way as for AIRS with surface and water vapour channels improving the most and a smaller change, but still in the right direction, for the temperature sounding channels.

The impact of adding MetOp-B IASI on top of the other MetOp-B instruments is around +0.13 in the global NWP index (see table 2). Referring to the second graph in figure 3, the RMS fit to observations is generally improved, although less than for the full MetOp-B comparison. Recall that this is for an approximately 20% increase in the number of IASI observations assimilated. The change in the fit to ATOVS, AIRS and MetOp-A IASI observations is shown in figure 5. As before the fit to water vapour sensitive channels is particularly improved, although not by as much as for full MetOp-B change. The only slight concern is that the fit to some of the AMSU-A temperature sounding channels is marginally worse.

For the comparison of thinning the two IASI instrument separately as opposed to together, table 2 indicates an addition impact of +0.06 on the new NWP index. The fit to observations in the Southern Hemisphere seems particularly improved according to the third plot in figure 3. Changing to thinning separately will result in a proportionately larger increase in the number of observations used towards the poles because the swaths overlap more in those regions. The pattern of the changes to the fit to ATOVS, AIRS and MetOp-A IASI is similar to before, but smaller in degree, see figure 6.

Verifying trial sjfsb against sjfsa gives the impact of adding a separately thinned IASI MetOp-B to a system that already includes MetOp-A IASI and MetOp-B ATOVS, ASCAT and AMVs. From table 2 the impact is +0.18. The lowest plot in figure 3 shows the change in RMS fit to observations for this case. The fit is improved in the majority of cases. Unlike previous comparisons there are three fields that are degraded by more than 2% in the extended verification table. These are for the temperature at 50 hPa in the tropics for the forecast ranges T+48, T+60, and T+72, although in fact all forecast ranges for the temperature at 50 hPa are degraded in the tropics. The 50 hPa heights are also degraded in the tropics, although to a lesser degree. The 50 hPa fields look neutral in the Northern Hemisphere and are slightly degraded in the Southern Hemisphere. The changes to other fields are either beneficial or not significant. The fit to ATOVS, AIRS and MetOp-A IASI are shown in figure 7 and follow a similar pattern to previous plots.

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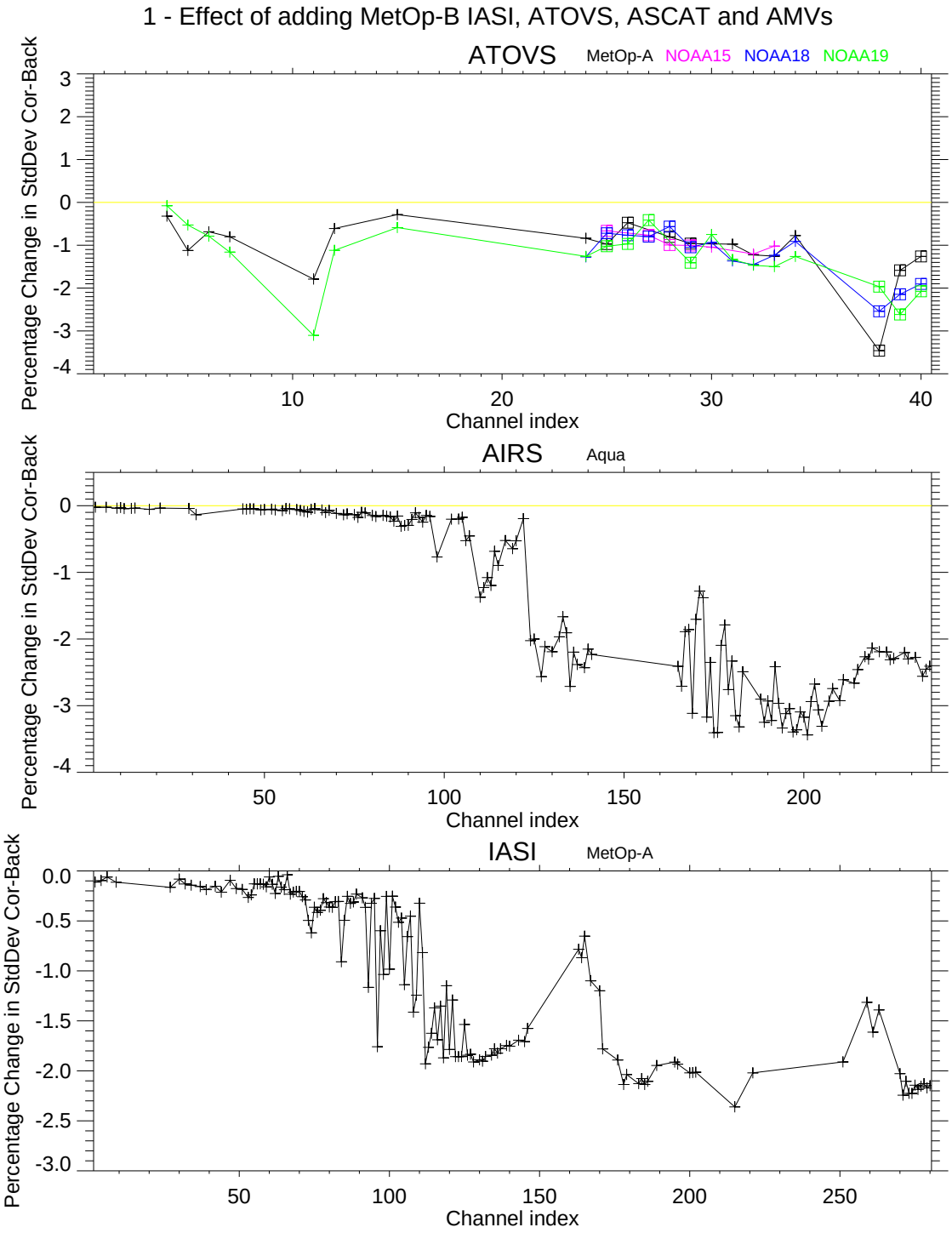

Figure 4: The percentage change in standard deviation of observed minus forecast for ATOVS, AIRS and MetOp-A IASI channels as a result of adding MetOp-B IASI, ATOVS, ASCAT and AMVs.

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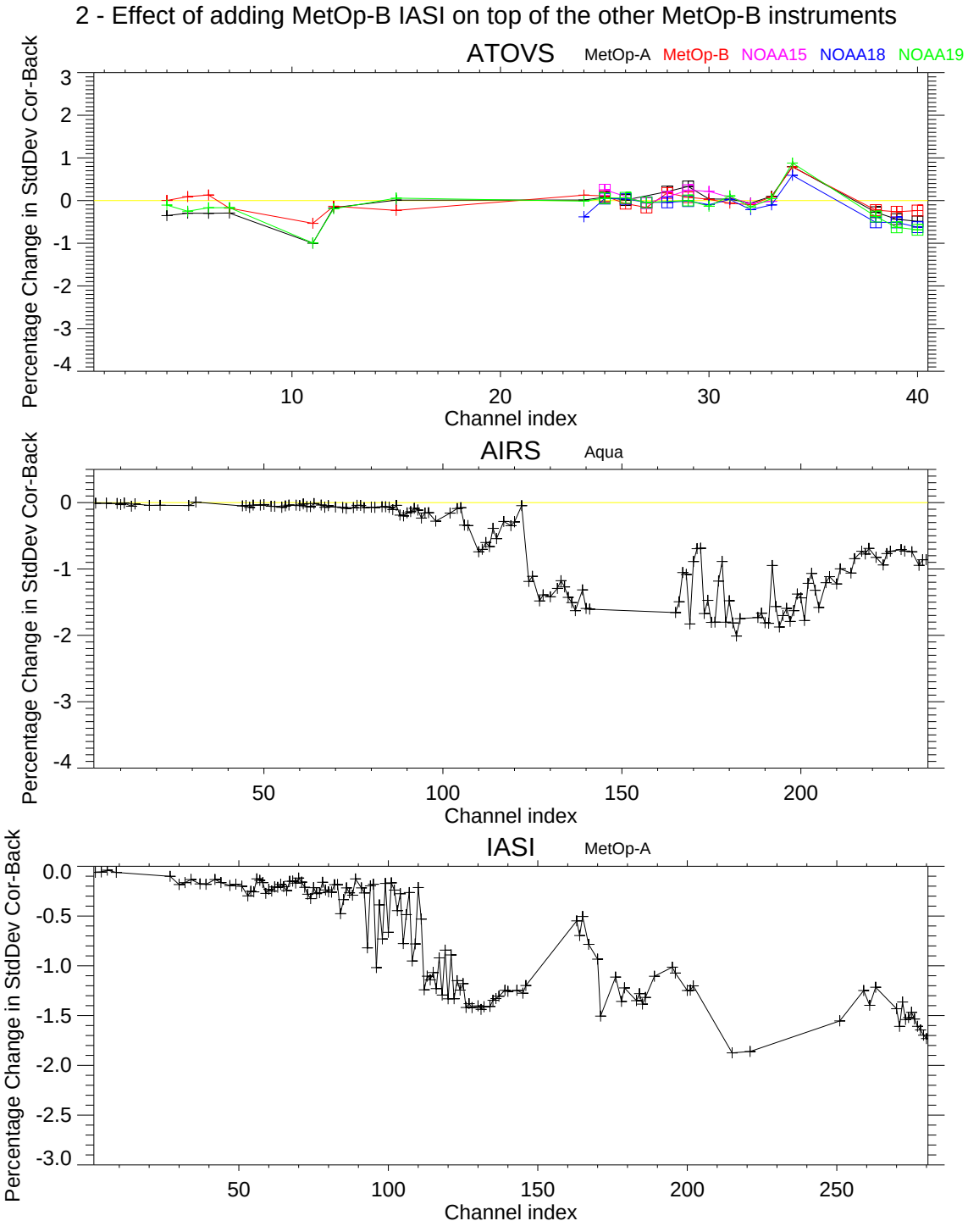

Figure 5: The percentage change in standard deviation of observed minus forecast for ATOVS, AIRS and MetOp-A IASI channels as a result of adding MetOp-B IASI on top of the other MetOp-B instruments.

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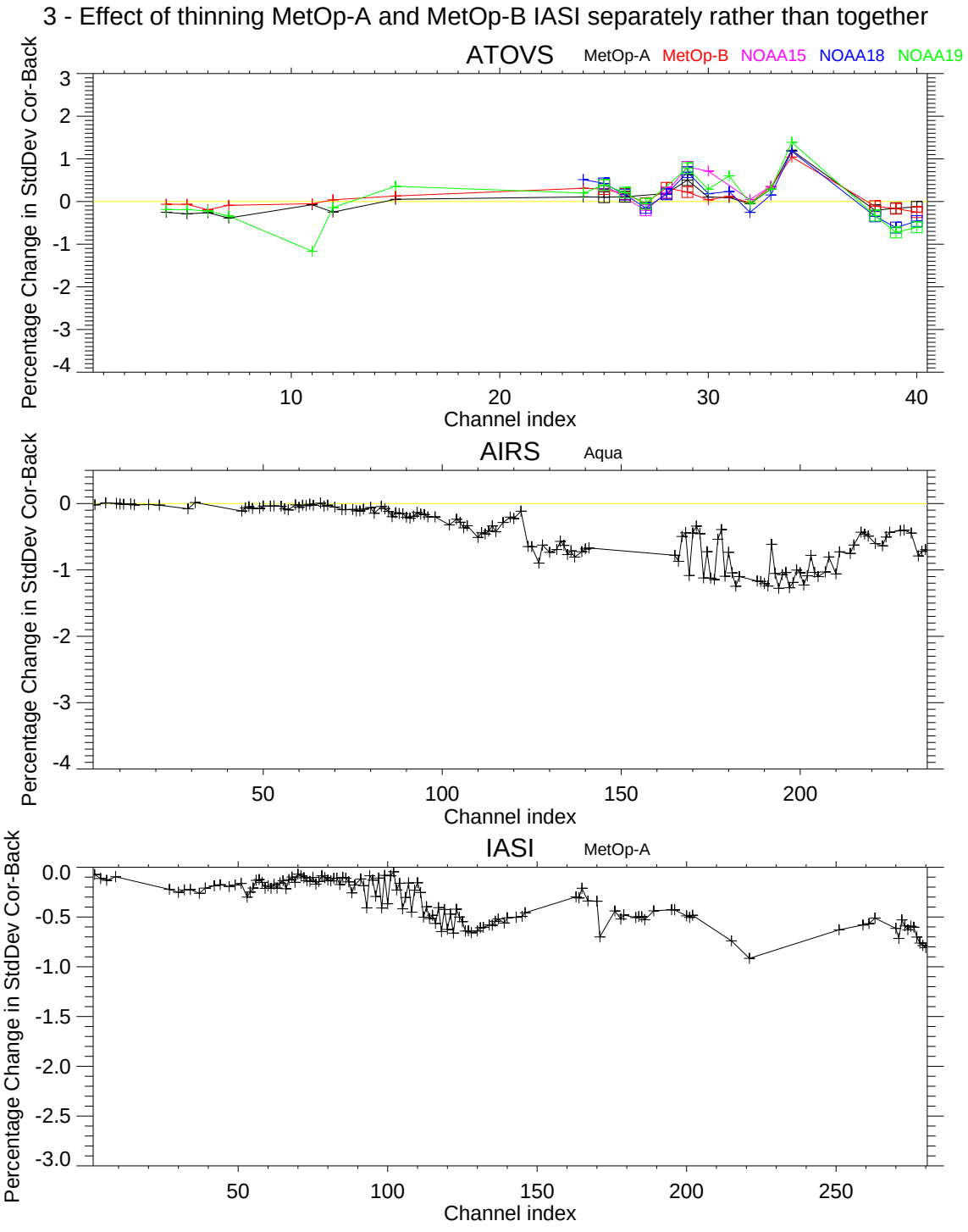

Figure 6: The percentage change in standard deviation of observed minus forecast for ATOVS, AIRS and MetOp-A IASI channels as a result of thinning MetOp-A and MetOp-B IASI separately rather than together.

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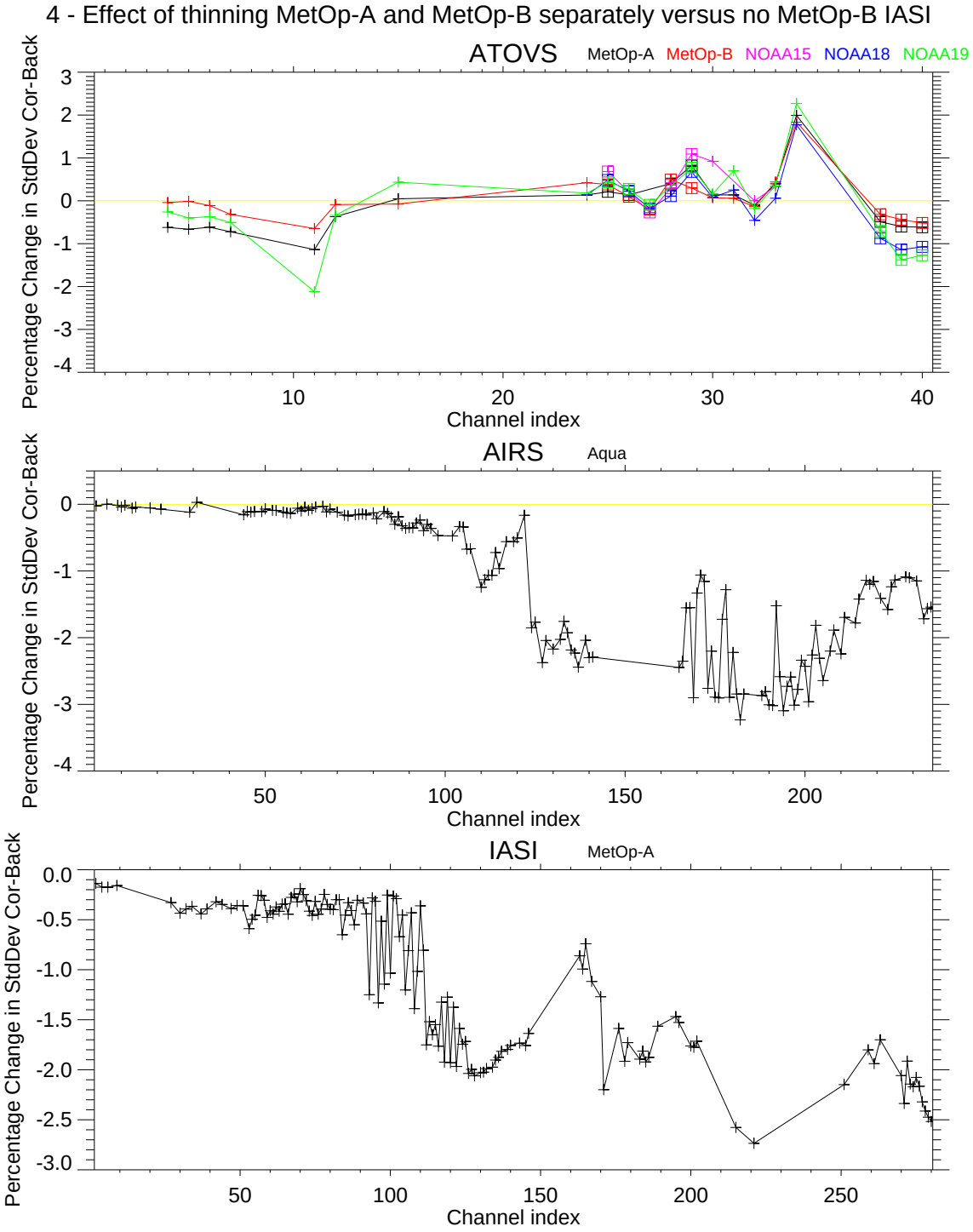

Figure 7: The percentage change in standard deviation of observed minus forecast for ATOVS, AIRS and MetOp-A IASI channels as a result of adding a separately thinned MetOp-B IASI.

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Thinning MetOp-A and MetOp-B IASI separately results in more IASI observations being passed to the assimilation system and therefore leads to the analysis drawing more closely to IASI observations as a whole. It is likely that a similar effect could be achieved by reducing the thinning distance applied to IASI observations. A reduction in the observation error used might also drive a closer fit to IASI observations, but if too small a value is used the analysis will be degraded. It is planned to increase the resolution of the VAR inner loop from N216 (60 km) to N320 (40 km) at PS34. The higher resolution analysis may benefit from reduced observation thinning.

As was noted in section 3 these trials use some of the earliest available MetOp-B IASI data. It would be desirable to run a second season, perhaps for late-summer 2013, to confirm the impacts discussed above.

5 Forecast sensitivity to MetOp-B IASI

Statistics on the sensitivity of the forecast to observations were collected for the period 23 March–25 April 2013. The method used is described in [2]. The experiment was configured as PS32, including hybrid assimilation, but with the forecasts run at N320 rather than N512 resolution. Figure 8 shows the impact of each observation type for a moist energy norm. It can be seen that the impact of MetOp-B IASI is about 20% of that of MetOp-A IASI, consistent with the ratio of the numbers of observations assimilated. Plots of the impact per channel and impact per sounding (not shown in this report) show very similar values for MetOp-A and MetOp-B IASI, strongly suggesting that MetOp-B IASI is delivering the expected impact.

6 Conclusions

Assimilating MetOp-B IASI data results in a 20% increase in the number of IASI observation assimilated. The data coverage is improved and the system will also be more robust to interruptions in the flow of data.

The impact of MetOp-B IASI observations on the forecast has been tested over the period 1 February–25 March 2013. Forecast verification indicates that the addition of MetOp-B IASI data gives a positive impact on the NWP index of around +0.13. A further impact of around +0.06 was found for thinning MetOp-A and MetOp-B IASI observations separately. The fit of forecast fields to observations is improved for most forecast fields and at most forecast ranges. The fit of the forecast background to ATOVS, AIRS and MetOp-A IASI observations is also generally improved, although the fit to some of the AMSU-A temperature sounding channels is marginally worse.

A forecast sensitivity experiment for the period 23 March–25 April 2013 indicates that the impact per observation for MetOp-B IASI is very similar to that of MetOp-A IASI. This is good evidence that MetOp-B IASI is delivering the expected impact.

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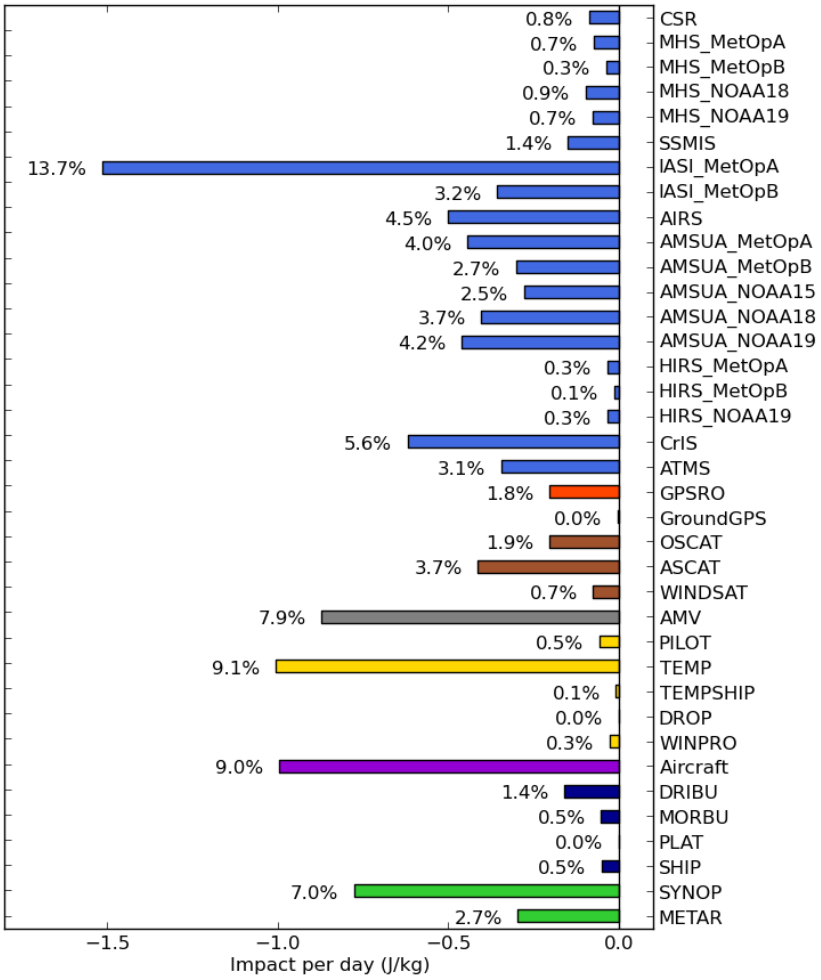

Figure 8: The mean impact per day of different types types of observation as derived from a forecast sensitivity experiment.

References

[1] James R. N. Cameron. Comparison of locally received MetOp-B IASI data with global MetOp-A IASI data. Forecasting Research Technical Report No: 575, 2013.

[2] Andrew C. Lorenc and Richard T. Marriott. Forecast sensitivity to observations in the Met Office Global numerical weather prediction system. *Q. J. R. Meteorol. Soc.*, 2013. DOI: 10.1002/qj.2122.

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